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MATHEMATICS.—*A simple formula for welding curves in graduating observational data.*[1] JOHN RICE MINER. (Communicated by RAYMOND PEARL.)

In smoothing data it often happens that a single curve will not fit the whole range satisfactorily and it is therefore necessary to fit different sub-ranges with different curves. As these curves will in general have different slopes at their points of intersection it will often be desirable, in order to avoid the discontinuity in the first derivative that this involves, to use some kind of welding formula which will make a less abrupt transition from the one curve to the other. This may be done by the use of two parabolic segments, each tangent to one of the curves and to the other segment. Let the interval over which the welding formula is to be used be $2n$. We know the ordinate, y_{-n}, and slope, y'_{-n}, of the first curve ϕ_1 at $x = -n$, and the ordinate, y_n, and slope, y'_n, of the second curve ϕ_2 at $x = n$. Our problem is then to find the coefficients of $f_1 = a_0 + a_1x + a_2x^2$ and $f_2 = b_0 + b_1x + b_2x^2$ so that

$$f_1(-n) = y_{-n}, f'_1(-n) = y'_{-n},$$

the condition that f_1 shall be tangent to ϕ_1 at $-n$

$$f_2(n) = y_n, f'_2(n) = y'_n,$$

the condition that f_2 shall be tangent to ϕ_2 at n

$$f_1(0) = f_2(0), f'_1(0) = f'_2(0),$$

the condition that f_1 and f_2 shall be tangent to each other at 0.

[1] Received January 28, 1926. Communication from the Institute for Biological Research of the Johns Hopkins University.

That is

$$a_0 - na_1 + n^2a_2 = y_{-n} \quad (1)$$
$$a_1 - 2na_2 = y'_{-n} \quad (2)$$
$$b_0 + nb_1 + n^2b_2 = y_n \quad (3)$$
$$b_1 + 2nb_2 = y'_n \quad (4)$$
$$a_0 = b_0 \quad (5)$$
$$a_1 = b_1 \quad (6)$$

Eliminating a_1 and a_2 respectively from (1) and (2), and b_1 and b_2 from (3) and (4)

$$2a_0 - na_1 = 2y_{-n} + ny'_{-n} \quad (7)$$
$$a_0 - n^2a_2 = y_{-n} + ny'_{-n} \quad (8)$$
$$2b_0 + nb_1 = 2y_n - ny'_n \quad (9)$$
$$b_0 - n^2b_2 = y_n - ny'_n \quad (10)$$

But from (5), (6), (7) and (9)

$$a_0 = b_0 = \frac{1}{2}(y_n + y_{-n}) - \frac{n}{4}(y'_n - y'_{-n}) \quad (11)$$

$$a_1 = b_1 = \frac{1}{n}(y_n - y_{-n}) - \frac{1}{2}(y'_n + y'_{-n}) \quad (12)$$

and from (8) and (10)

$$a_2 = \tfrac{1}{n^2}(a_0 - y_{-n} - ny'_{-n}) \quad (13)$$
$$b_2 = \tfrac{1}{n^2}(b_0 - y_n + ny'_n) \quad (14)$$

As an example we may take the values of $1000q_x$ for material in course of reduction in this laboratory. Up to 57 years these are fitted with[2]

$$y = 6.795e^{0.1066x}$$

which at 57 years has an ordinate of 13.449, and a slope of 0.287 per year, while from 63 years up they are fitted with[2]

$$y = 264 - 113x + 14.4x^2 - 0.48x^3$$

which at 63 years has an ordinate of 26.236, and a slope of 4.541 per year.

Therefore $n = 3$,

$$a_0 = b_0 = \tfrac{1}{2}(26.236 + 13.449) - \tfrac{3}{4}(4.541 - 0.287)$$
$$= 19.843 - 3.191 = +16.652$$
$$a_1 = b_1 = \tfrac{1}{3}(26.236 - 13.449) - \tfrac{1}{2}(4.541 + 0.287)$$
$$= 4.262 - 2.414 = +1.848$$
$$a_2 = \tfrac{1}{9}(16.652 - 13.449 - 3 \times 0.287) = +0.2602$$
$$b_2 = \tfrac{1}{9}(16.652 - 26.236 + 3 \times 4.541) = +0.4488$$

[2] These equations are taken with origin at 25 years and with a five-year interval for the x unit.

The ordinates for the different years are therefore as shown in Table 1.

TABLE 1.—ORDINATES

YEAR	x	$1000\eta_x$
57	−3	13.45
58	−2	14.00
59	−1	15.06
60	0	16.65
61	+1	18.95
62	+2	22.14
63	+3	26.24

SPECTROSCOPY.—*Arc spectrum regularities for ruthenium.*[1] W. F. MEGGERS AND OTTO LAPORTE, Bureau of Standards.

In a preliminary note on this subject the authors described[2] underwater-spark observations which led to the identification of the lowest term in the ruthenium spectrum. This was a 5-fold term with separations 392.2, 621.7, 900.9, 1190.8 cm.$^{-1}$, which from analogy with the structure of the iron spectrum was regarded as a quintet-D term. The lack of Zeeman-effect data for the identification of absolute quantum numbers was deprecated and it was announced that new observations were being made in coöperation with Prof. B. E. Moore of the University of Nebraska. The untimely death of Professor Moore interrupted these experiments, but the kind offer of Prof. H. H. Marvin to continue them finally put us in possession of some data. Meanwhile L. A. Sommer in Göttingen has also observed[3] some Zeeman patterns for ruthenium lines, and has indicated that the lowest term is in reality a quintet-F term, requiring that all our quantum numbers be increased by one unit. This has been confirmed by our own measurements, some of which appear in Table 2. The purpose of this paper is to make this correction and to extend the analysis of the arc spectrum of ruthenium.

There are presented in Table 1 eighteen multiplets which have been selected as representative of quintet, triplet, and inter-system combinations. The notation[4] here employed is that which is now in

[1] Published by permission of the Director of the Bureau of Standards of the Department of Commerce.

[2] Science, **61**: 635. 1925.

[3] Die Naturwissenschaften, **13**: 840. 1925.

[4] Astrophys. Journ., **61**: 60. 1925.

TABLE 1.—MULTIPLETS IN THE RU I SPECTRUM

	$^5F_5$ 1190.8	$^5F_4$ 900.9	$^5F_3$ 621.7	$^5F_2$ 392.2	$^5F_1$
$^5D_4$	3799.34(8)a	3979.44(5)	4127.46(3)		
	26312.9	25122.1	24221.2		
1194.0					
$^5D_3$		3798.90(8)a	3933.55(4)	4032.21(3)	
		26316.0	25415.2	24793.3	
969.2					
$^5D_2$			3790.50(10)a	3882.00(3)	3942.06(3)
			26374.3	25752.6	25360.3
652.9					
$^5D_1$				3786.05(10)a	3843.07(3)
				26405.3	26013.4
451.1					
$^5D_0$					3777.58(3)a
					26464.5
$^5F_5'$	3728.03(10R)a	3901.24(4)			
	26816.2	25625.6			
1198.7					
$^5F_4'$	3568.47(1)	3726.93(10R)a	3856.39(3)		
	28015.2	26824.1	25923.7		
875.5					
$^5F_3'$		3609.10(2)	3730.44(4)a	3819.04(4)	
		27699.9	26798.9	26177.2	
536.9					
$^5F_2'$			3657.17(2)	3742.29(10)a	3798.06(3)
			27335.8	26714.0	26321.8
266.2					
$^5F_1'$				3705.36(2)	3760.03(4)
				26980.3	26588.0

TABLE 1—*Continued.*

	$^5F_5$	1190.8	$^5F_4$	900.9	$^5F_3$	621.7	$^5F_2$	392.2	$^5F_1$
$^5G_6$	*3498.95(50R)a 28571.8								
1707.9									
$^5G_5$	3301.59(8)a 30279.7		*3436.74(30R)a 29089.0						
−388.8									
$^5G_4$	3344.53(3) 29891.0		3483.32(4) 28700.1		3596.17(20)a 27799.4				
646.2									
$^5G_3$			3406.59(2) 29346.5		3514.50(3)a 28445.4		3593.03(20)a 27823.7		
421.8									
$^5G_2$					3463.14(3) 28867.2		3539.37(4)a 28245.5		3589.23(5)a 27853.2
$^3D_3$			3348.69(2) 29853.8		3452.91(3) 28952.8		3528.70(5) 28331.0		
1163.2									
$^3D_2$					3319.52(1) 30116.2		3389.50(3) 29494.5		3435.20(3) 29102.1
1372.5									
$^3D_1$							3238.77(2) 30867.0		3280.46(3) 30474.7
$^5F_4'$	3294.13(10)a 30348.3		3428.65(4)a 29157.7		3537.96(5)a 28256.9				
2043.6									
$^5F_3'$			3204.04(2) 31201.6		3299.34(2) 30300.4		3368.45(8)a 29678.8		
780.0									
$^5F_2'$					3216.61(3) 31080.6		(?) 30458.8		3325.00(3) 30066.6

TABLE 1—*Continued.*

	$^5F_5$ 1190.8	$^5F_4$ 900.9	$^5F_3$ 621.7	$^5F_2$ 392.2	$^5F_1$
$^5G_6$	(?)	3661.34(6)a			
	28495.2	27304.6			
1395.9					
$^5G_4$	3304.81(2)	3440.22(3)	3550.28(3)		
	30250.2	29059.6	28158.8		
1962.0					
$^5G_3$		3260.36(5)a	3359.09(5)a	3430.77(5)a	
		30662.6	29761.5	29139.7	

	$^3D'_4$ 1092.6	$^5D'_3$ 608.2	$^5D'_2$ 436.6	$^5D'_1$?	$^5D'_0$
$^5D_4$	5309.26(20)	5636.23(35)			
	18829.8	17737.5			
1194.0					
$^5D_3$	4992.73(7)	5280.81(4)	5456.13(8)		
	20023.6	18931.2	18322.9		
969.2					
$^5D_2$		5026.17(8)	5184.72(2)	5304.85(7)	
		19890.3	19282.1	18845.5	
652.9					
$^5D_1$			5014.95(8)	5127.25(5)	(?)
			19934.8	19498.2	(?)
451.1					
$^5D_0$				5011.22(9)	
				19949.7	

$^5F_5'$	5171.02(40)				
	19333.2				
1198.7					
$^5F_4'$	4869.16(25)	5142.76(8)			
	20531.7	19439.4			
875.5					
$^5F_3'$	4669.96(8)	4921.08(12)	5072.97(7)		
	21407.5	20315.1	19706.8		
536.9					
$^5F_2'$		4794.38(4)	4938.43(10)	5047.30(6)	
		20851.9	20243.7	19807.1	
266.2					
$^5F_1'$			4874.33(3)	4980.35(9)	
			20509.9	20073.3	(?)

TABLE 1—*Continued.*

	$^5D'_4$	1092.6	$^5D'_3$	608.2	$^5D'_2$	436.6	$^5D'_1$	?	$^5D'_0$
$^5G_6$									
1707.9									
$^5G_5$	4385.40(4) 22796.6								
−388.8									
$^5G_4$	(?) 22407.9		4690.11(5) 21315.5						
646.2									
$^5G_3$	4336.42(2) 23054.0		4552.10(5) 21961.7		4681.79(10) 21353.4				
421.8									
$^5G_2$			4466.34(1) 22383.4		4591.11(6) 21775.2		(?) 21338.6		

	$^5P_3$	− 727.1	$^5P_2$	1029.2	$^5P_1$
$^5D_4$	5699.06(20) 17541.9				
1194.0					
$^5D_3$	5335.92(10) 18735.7		5136.55(25) 19462.9		
969.2					
$^5D_2$	5076.07(5) 19694.8		4895.28(6) 20422.2		5155.12(12) 19392.8
652.9					
$^5D_1$			4743.66(1) 21074.9		4987.25(5) 20045.5
451.1					
$^5D_0$					4877.41(3) 20496.7

TABLE 1—*Continued.*

	$^5P_3$	— 727.1	$^5P_2$	1029.2	$^5P_1$
$^5F_5'$					
1198.7					
$^5F_4'$	5195.01(10) 19243.9				
875.5					
$^5F_3'$	4968.87(7) 20119.7		4795.57(6) 20846.8		
536.9					
$^5F_2'$	4839.75(4) 20656.5		4675.19(1) 21383.5		4911.58(3) 20354.4
266.2					
$^5F_1'$			4617.66(3) 21650.0		4848.17(2) 20620.6
$^5G_6$					
1707 9					
$^5G_5$					
−388.8					
$^5G_4$	4733.47(12) 21120.3				
646.2					
$^5G_3$	4593.08(1) 21765.8		4444.50(3) 22493.4		
421.8					
$^5G_2$	4505.64(1) 22188.2		4362.71(1) 22915.1		4567.92(1) 21885.7

TABLE 1—*Continued.*

	$^3F_4$	1539.4	$^3F_3$	973.4	$^3F_2$
$^3D_3$	4080.63(20) 24499.2		4354.14(5) 22960.2		4546.93(1) 21986.7
1163.2					
$^3D_2$			4144.18(10) 24123.4		4318.43(3) 23150.0
1372.5					
$^3D_1$					4076.75(8) 24522.5
$^3F_4'$	4199.91(10)a 23803.3		4490.22(3) 22264.4		
2043.6					
$^3F_3'$	3867.82(8) 25847.1		4112.76(8) 24307.8		4284.34(5) 23334.3
780.0					
$^3F_2'$			3984.86(10) 25087.9		4145.75(8) 24114.3
$^3G_5$	4554.52(50)a 21950.1				
1755.0					
$^3G_4$	4217.28(5) 23705.3		4510.12(8) 22166.2		
1602.6					
$^3G_3$	3950.22(3) 25307.9		4206.02(5) 23768.8		4385.66(4) 22795.2

TABLE 1—*Continued.*

	$^5F_4$	1539.4	$^5F_3$	973.4	$^5F_2$
$^5D_4$	5057.33(30) 19767.8		5484.33(10) 18228.7		
1194.0					
$^5D_3$	4769.30(9) 20961.6		5147.24(10) 19422.5		5418.85(6) 18449.0
969.2					
$^5D_2$			4905.01(4) 20381.7		5151.06(8) 19408.1
652.9					
$^5D_1$					4983.44(4) 20060.9
451.1					
$^5D_0$					
$^5F_5'$	4931.72(0) 20271.3				
1198.7					
$^5F_4'$	4656.42(3) 21469.7		5015.99(0) 19930.7		
875.5					
$^5F_3'$	4473.92(4) 22345.5		4804.87(8) 20806.4		5040.74(6) 19833.3
536.9					
$^5F_2'$			4684.02(10) 21343.2		4907.88(8) 20369.8
266.2					
$^5F_1'$					4844.54(9) 20636.0

TABLE 1—*Concluded.*

	$^5F_4$	1539.4	$^5F_3$	973.4	$^5F_2$
$^5G_6$					
1707.9					
$^5G_5$	4212.08(10) 23734.6				
−388.8					
$^5G_4$	4282.20(2) 23346.0		4584.45(30) 21806.8		
646.2					
$^5G_3$	4166.88(3) 23992.1		(?) 22452.9		4654.31(10) 21479.5
421.8					
$^5G_2$			4370.42(2) 22874.7		4564.69(5) 21901.2

common use for the symbolical description of regularities in line spectra except that the letters S, P, D, F, G are understood to correspond to l values 1, 2, 3, 4, 5, respectively, l representing the quantized sum of the k values of all the individual electrons. The spectral term symbols are shown at the margins together with the separations of the sub-levels. Wave lengths in air, intensity estimates (in parentheses) and wave numbers in vacuum represent the spectral data, the measurements of Kayser[5] being used from the ultraviolet to 4500A and those of Meggers[6] for the longer waves. Because of the larger scale of intensities given by Exner and Haschek[7] their estimates have been quoted instead of Kayser's. Lines which we have observed as absorbed in under-water-spark spectra are marked *a;* the *raies ultimes* are indicated by asterisks. The present grouping of the higher levels depends, in a few cases, on the rules for spectral line intensities and separations of sub-levels, and since it has been shown that these rules are frequently violated in spectra of the heavier atoms it may be necessary to revise some of the higher level groups when more conclusive data are available. A host of still higher levels has been found but

[5] Astrophys. Journ., **7**: 101. 1898.
[6] Bur. Stand. Sci. Pap., **20**: 20. 1925.
[7] Spektren der Elemente bei normalem Druck II: 212. 1911.

these are reserved until further Zeeman-effect observations permit unambiguous assignment of their l values.

For the purpose of observing Zeeman effects an alloy of ruthenium and platinum was prepared by Dr. E. Wichers of this Bureau. Electrodes of this alloy were supplied to the Brace Laboratory of Physics where the exposures were made, the films being returned to the Bureau of Standards for measurement. Between the wave-length limits 3428 and 4552A the Zeeman patterns of 34 ruthenium arc lines were photographed. Most of these naturally involve the low ^5F term since the strongest lines of the spectrum originate with this term. On account of the relatively large quantum numbers the majority of lines are very complex in a magnetic field and are therefore difficult to resolve; only those involving the quantum transition $j \rightarrow j$ between terms of the same l values are simple triplets. Some of the latter and two unaffected lines are listed in Table 2. The separations are expressed

TABLE 2.—ZEEMAN EFFECTS FOR RUTHENIUM LINES

λ	COMBINATION	ZEEMAN EFFECT	
		Observed	Theoretical
3726.93	$^5F_4 - {}^5F_4'$	(0) 1.36	(0) 1.35
3728.03	$^5F_5 - {}^5F_5'$	(0) 1.40	(0) 1.40
3730.44	$^5F_3 - {}^5F_3'$	(0) 1.26	(0) 1.25
3742.29	$^5F_2 - {}^5F_2'$	(0) 1.05	(0) 1.00
3760.03	$^5F_1 - {}^5F_1'$	(0) 0	(0) 0
3777.58	$^5F_1 - {}^5D_0$	(0) 0	(0) 0
4112.76	$^3F_3 - {}^3F_2'$	(0) 1.16	(0) 1.08
4145.75	$^3F_2 - {}^3F_2'$	(0) 0.69	(0) 0.67
4199.91	$^3F_4 - {}^3F_4'$	(0) 1.27	(0) 1.25

in terms of a normal triplet; the perpendicular components follow the parallel ones which are enclosed in parentheses. Comparison of the observed and theoretical patterns shows that the Landé[8] g values are fairly well represented by these particular levels. Considerably larger deviations may be expected for the Zeeman effects of lines involving the higher terms.

The spectral terms for ruthenium, like those for iron, are inverted but the separations of the sub-levels are much larger. After assigning the value zero to $^5F_5$, which is the lowest energy level of the normal ruthenium atom, the relative values of the levels combining to give the multiplets of Table 1 were computed. These relative term values and the corresponding term symbols are presented in Table 3. The

[8] Zeit. f. Physik, 15: 189. 1923.

interval rule cannot be said to be obeyed by any of these terms although most of the low levels satisfy the rule better than the higher ones. Thus the low ^5F term has separation ratios 5:3.8:2.6:1.6, the higher $^5F'$ has ratios 5:3.6:2.2:1.1, whereas the rule in both cases requires 5:4:3:2. Similarly ^3F has separations in the ratio 5:3.2, and $^3F'$ in the ratio 5:1.9; both should be 5:4 according to rule. Attention is called especially to the irregular intervals 1707.9, −388.8, 646.2, 421.8 in the ^5G term and −727.1, 1029.2 in the ^5P term. In the arc spectrum of iron where, in general, the interval rule is more exactly fulfilled, the strictly analogous terms are also irregular as to their separations. They are −61.5, 474.9, 354.3, 244.8 for ^5G and 176.8, 200.4 for ^5P.

TABLE 3.—Relative Terms in the Ru I Spectrum

$^5F_5$	0.0	$^5D_2$	28466.0
$^5F_4$	1190.8	$^3G_5$	28495.4
$^5F_3$	2091.7	$^5G_6$	28571.8
$^5F_2$	2713.4	$^5F_3'$	28890.7
$^5F_1$	3105.6	$^5D_1$	29118.9
$^3F_4$	6545.0	$^5F_2'$	29427.5
$^5D_4'$	7483.0	$^5D_0$	29570.1
$^5P_2$	8044.0	$^5F_1'$	29693.8
$^3F_3$	8084.4	$^5G_4$	29891.0
$^5D_3'$	8575.6	$^3G_4$	30250.4
$^5P_3$	8771.1	$^5G_3$	30279.8
$^3F_2$	9057.8	$^3F_4'$	30348.5
$^5P_1$	9073.2	$^5G_3$	30537.2
$^5D_2'$	9183.8	$^5G_2$	30959.0
$^5D_1'$	9620.4	$^3D_3$	31044.4
$^5D_0'$	?	$^3G_3$	31853.0
$^5D_4$	26312.9	$^3D_2$	32207.8
$^5F_5'$	26816.3	$^3F_3'$	32392.1
$^5D_3$	27506.8	$^3F_2'$	33172.2
$^5F_4'$	28015.2	$^3D_1$	33580.3

From the relative terms recognized in the arc spectrum of ruthenium, we draw the following conclusions as to their characteristic electron configurations. Since the normal configurations of nearly all the atoms in the second half of the fifth period are demonstrated to be of the type[9] $z-1$ d and one s electrons, we may expect the same for ruthenium also. The low metastable terms found in the Ru I spectrum confirm this, and the presence of $^5D'$ shows also the relatively

[9] z denotes the number of valence electrons, e.g., 8 for Ru. The notation s, p, d, is used for 5_1, 5_2, and 4_3 electrons respectively.

high stability of a configuration of six d and two s electrons which, as is well known, represents the normal state of the analogous iron atom. The configuration seven d and one s furnishes the terms ^5F, ^3F, ^5P, ^3P, ^3H, etc.; the first three of which have been identified, and parts of a ^3P are found. There are also indications of another ^3F term, which must be accounted for by a configuration of eight d and no s electrons. The higher terms which combine with the terms discussed above, viz., ^5G, $^5F'$, ^5D, ^3G, $^3F'$, ^3D, by their occurrence in "triads," reveal their origin as the consequence of the addition of a p electron (5_2) to a ^4F in Ru II. But this ^4F term is indeed supposed to be the normal state in Ru II, belonging to the configuration of seven d electrons.[10] We therefore account for all the higher levels presented in this paper by an arrangement of seven d and one p electrons.

PALEONTOLOGY.—*Description of remains of an elephant found at Port Williams, Washington.* OLIVER P. HAY, Carnegie Institution of Washington.

From Professor Howard S. Brode, of Whitman College, Walla Walla, Washington, the writer received for examination a part of a collection of elephant remains made several years ago by Rev. Myron Eells at Port Williams, Clallam County, Washington. This place is on the southern shore of the eastern end of the Strait of San Juan de Fuca. The writer has learned nothing regarding the geology of the locality. Professor Brode informs the writer that Rev. Myron Eells was a missionary among the Twana and Clallam Indians for over 30 years. He collected much ethnological material, many fossils, and natural history specimens. He also wrote about 18 books and articles of considerable length.

The collection made by Mr. Eells consists of two third molars, an upper and a lower, which are referred to *Elephas columbi*, a fragment of a skull, which is here described, and tusks, one small and some others of large size. These tusks the writer has not seen. They may belong to *E. columbi* or to the elephant forming the subject of this paper. I regard the skull as belonging to a hitherto undescribed species, and, with the intention of honoring the finder, I name it *Elephas eellsi*.

At first view the specimen is an unpromising one. It consists of a part of the left maxilla and a smaller part of the right. The left portion presents the bone from the midline to the outside of the

[10] Kiess and Laporte, Science, 63: 234, 1926.

sheath of the tusk; further backward, to the middle of the infraorbital foramen and the rim of the orbit; thence backward and inward, to the rear of the alveolar border. The palatal portion extends backward to the maxillo-palatine suture. The damaged alveolar border retains sockets for some of the fangs of the teeth. Mesiad of the rear of the aveolar border, the palatal portion of the maxilla is missing to within about 28 mm. of the midline. On the right side the palatal border of the maxilla is present a distance of 150 mm., nearly to its union with the palatine bone. Viewed from above the specimen shows a part of the inner surface of the sheath of the left tusk and a multitude of air sinuses.

This fragment of skull presents some characters which the writer has seen in no other elephant. The principal of these is found in the structure of the palate. As in other elephants, there is in front, on each side, a prominent, sharp ridge, the continuation forward of the alveolar border. In the specimen these ridges, where closest, are about 30 mm. apart. Between these points of closest approach and the front of the tooth rows the palate rises about 25 mm. to the anterior palatine fissure, the sloping sides being at an angle of about 80° with each other. A little behind the palatine fissure the downward and outward slope amounts to 73 mm. The result is that, near the front of the tooth row, the midline of the palate is at least 50 mm. higher than its lateral borders. The damaged condition of the bone precludes any definite statement regarding the height farther back. At least, however, the sockets for the fangs of the root become shallower backward, and it is probable that the palate was high and vaulted throughout its length. Its width at the front of the tooth rows appears to have been a little more than 75 mm. The alveolar borders appear to have diverged rapidly backward. Measured from the maxillo-palatine suture to the anterior palatine fissure, the palate is 140 mm. long. Throughout most of this course it is straight along the midline, but as it approaches the palatine fissure it curves upward.

It is difficult to determine much that is certain about the teeth of this animal. On the left side, towards the front, is an opening due to the loss of bone (Fig. 1, inner *d.s.*). Evidently, on both sides, a considerable part of the lower edge of each alveolar border is broken away. On the right side (left in the figure) a depression is seen at the front of this border. This appears to have received the front fang of whatever tooth was present; not, however, necessarily the front root found in a little-worn tooth. On the left side are better indications of the fangs and their sockets. In front is a rough

Figs. 1 and 2.—Fragment of skull of *Elephas eelleri*.
(For description see page 157.)

surface which probably corresponds to the front socket of the right side. The left alveolar border stands about 20 mm. in front of that of the right side, the left tooth being apparently more advanced than the other.

Farther back on the left side, near the outside of the alveolar border, is a socket which retains a fang about 35 mm. long, 18 mm. from side to side, and 11 mm. from front to rear (Fig. 1, *d.f.*, upper guide line). Mesiad of this (*d.s.*, upper guide line) is the front and outer wall of another socket. Just behind these is another pair of sockets, the outer one shallow, the inner one 50 mm. deep. Still farther in the rear, on the outer side of the alveolar ridge, is another fang in its socket (*d.f.*, lower guide line). The lower guide line of the inner *d.s.* leads to what is apparently a partial socket, paired with the outer one containing the fang. Between the two is a hole which is apparently factitious. From this opening, a ridge, smooth on its steep front and its sloping rear, runs inward and backward. Behind the ridge is another partial socket (lower *d.s.*). The writer concludes that probably the alveolar border of each side bore a second molar tooth, that the partial socket in front, on the right side received the larger inner front root and that on the left side the partial socket is the scar left by the absorbed outer front root. The other sockets and the snags belonged apparently to three pairs of small fangs. Between the hinder pair of these and the great hinder root was a notch which was occupied by the outer end of the transverse ridge above described.

In elephants there is usually, on each side, between the alveolar border and the base of the sheath of the tusk, an excavation, or fossa, of little depth. In the specimen under consideration the front of the alveolar border rises perpendicularly about 70 mm. to the summit of the fossa and then curves outward and upward to the front of the infraorbital foramen. In a specimen of *Elephas primigenius* found many years ago at Pastolik, Alaska, by Dr. W. H. Dall, the roof of this

Fig. 1.—Specimen seen from below × 0.4: *alvb*, alveolar border; *a.p.f.*, anterior palatine fissure; *d.f.*, dental fang; *d.s.*, dental socket; *inf. for.*, infraorbital foramen. The line from *alvb.* traverses the front socket of a part of the root of the tooth. It ends at the summit (as seen from below) of the alveolar border. On the opposite side the corresponding point is in front of the anterior fang indicated by *d.f.* In front of *d.s.*, upper guide line, are seen indications of the foremost socket of that side.

Fig. 2.—Specimen seen from in front and below: abbreviations as in Fig. 1: *d.s.*, the guide-lines run to the right and left anterior sockets; *d.f.*, indicates the first fang present. In this figure the smooth surface just below the word "tusk" was in contact with the tusk; elsewhere are seen the air sinuses.

fossa extends outward nearly horizontally beneath the sheath and curving around meets at nearly a right angle the lateral face of the sheath just in front of the infraorbital foramen. In the Alaska specimen the lower border of the foramen is only about 90 mm. above the front end of the alveolar border; in the Port Williams skull the corresponding distance is about 120 mm.

Of the sheath of the tusk there remains only the lower and outer part of its base. It is estimated that the diameter of the tusk was about 4 inches. Of the bone in actual contact with the tusk there is left only a patch 90 mm. long. This is seen in figure 2 of the plate just below the word "tusk." The removal of the rest has exposed the air cells between the inner and outer layers of compact bone.

The writer finds that the different species of elephants, so far as he has examined them, have each a form of palate more or less different from that of other species. The palate of the African elephant is broad behind and narrows rapidly forward. From front to rear it is slightly concave. From side to side it is concave, but the concavity may be interrupted by a low median ridge. In the Indian elephant the palate is somewhat convex from front to rear, but there may be at one or both ends a short concavity. From end to end it is traversed by a prominent median ridge, on each side of which is a groove. Cross-sections, therefore, present right and left concavities. The alveolar borders are more nearly parallel than they are in the African species.

The elephant brought by Doctor Dall from Pastolik has a peculiar palate. Between the anterior palatine fissure and the front of the teeth it is strongly concave; in the space between the front ends of the alveolar borders the palate is flat; farther back it becomes strongly convex as far as the maxillo-palatine suture. From end to end, then, the palate presents a pronounced sigmoid curve. At the front of the flat portion a median ridge begins which increases in height backward. In front the alveolar borders are on a level with the palate, but backward they descend, so that near the maxillo-palatine suture they are 35 mm. below the palate. In this region there is, therefore, a broad, deep groove on each side of the palate.

In the U. S. National Museum is a fine skull of *Elephas primigenius* from Siberia. It is mounted for exhibition and the iron supports conceal the palate to such an extent that a view of it can hardly be obtained; but so far as can be determined, the palate is like that of the Pastolik specimen.

In his work on the frozen elephant found in Beresovka River, Siberia,[1] Dr. W. Salensky furnished a figure of the skull as seen from below. The palate, as seen in that figure, presents no such construction as does that of the Pastolik specimen. It appears to have been quite flat from end to end and from side to side. The Pastolik animal has a palate only about 60 mm. wide, with the sides parallel. The Beresovka elephant's palate appears to be 80 mm. wide in front and wider behind. These deviations from the palate of *E. primigenius* appear to confirm the writer's conclusion arrived at in 1922[2] from the thickness of the plates of the teeth that Salensky's elephant did not belong to *E. primigenius*, but was then an unnamed species. This was accordingly called *Elephas beresovkius*.

In the U. S. National Museum is the type of *Elephas boreus*. As in the case of the Siberian specimen the iron supports prevent any determination of the structure of the palate. It is possible that the method of mounting the skull of the great elephant of the same species in the American Museum of Natural History, at New York, will permit an examination of the palate. This elephant was found in Indiana and is nearly complete. It is worthy of being regarded as the plesiotype of the species *Elephas boreus*.

In the U. S. National Museum is a part of a skull of *Elephas imperator* from an unknown locality. It presents the palate and the two fine hindmost molars. From the anterior palatine cleft to the rear of the palate the midline is nearly straight. This, however, is the crest of a prominent ridge, low in front, but increasing in height to the maxillo-palatine suture, then decreasing. On each side of this is a groove whose depth at the suture mentioned is quite an inch. The borders of the palate descend somewhat below the median ridge. The length of the palate is 12.5 inches; its width at the rear, 4.5 inches.

A specimen of an elephant found at Buckeye, Matagorda County, Texas, whose teeth indicate *E. imperator*, has a palate much like the one just described, as is shown by a cast sent me by Dr. Mark Francis. A photograph of the palate of *Elephas roosevelti*, as represented by a palate and teeth at Milwaukee, shows so much at least that its palate is different from that of *Elephas eellsi*. I have not had the opportunity to examine the palate of *E. columbi*.

[1] Scientific Results, etc., 1903, pl. VI, fig. 45.

[2] Observations on some extinct elephants, p. 4.

BOTANY.—*New South American species of Rubus.* ALWIN BERGER, New York State Agricultural Experiment Station, Geneva, N. Y. (Communicated by A. S. Hitchcock.)

The United States National Herbarium is rich in South American material of the genus *Rubus*, the extensive collections of J. N. Rose, A. S. Hitchcock, F. W. Pennell, and E. P. Killip having been recently added to it. In view of the investigations which I have been carrying on in this genus all of this material was sent me, and I have thus had an opportunity for thorough study. Although convinced that the collection contains several new species and forms, I hesitate to describe more than the following.

Rubus gachetensis Berger, sp. nov.

Rami floriferi teretes, breviter dense griseo-tomentosi aculeis parvis sparsis recurvis armati; rami steriles desunt. Stipulae ovatae, obtusae. Folia ternata, suprema subtriloba vel simplicia; petioli 1 cm. longi, tomentosi, parce aculeati petiolulus medius fere aequilongus; foliola obovata, obtusa, coriacea, supra glabra nitidula vel minute puberula, subtus griseo-tomentosa, in costa media parce aculeata, costis lateralibus utrinque 6, (5–7) margine recurvulo inaequaliter crenato-serrata, foliola terminalia, 4-5 cm. longa, 3 cm. lata. Ramuli floriferi axillares et terminales 3–5-flori; pedicelli 1–3 cm. longi, villoso-tomentosi, aculeis recurvis armati. Calyces tomentosi, sepalis ovato-deltoideis 6 mm. longis, petala duplo longiora rubra.

COLOMBIA: Camino de Gachetá, in forests, alt. 2300 m. *Brother Ariste-Joseph* A543.—Flowering, January 1920. (Type, U. S. National Herbarium, no. 1,059,773.)

Species subgeneris "Orobatus" Focke, *Rubo mandonii* affinis, differt foliolis coriaceis, obtusis, paucinerviis etc.

Rubus choachiensis Berger, sp. nov.

Fruticosus, ut videtur decumbens. Rami teretes, ut petioli, petioluli etc. dense tomentosi aculeisque minutis recurvis parum numerosis asperi. Folia ternata. Stipulae magnae ovatae, acutae, integrae vel subcrenulatae. Petioli 3–4 cm. longi, petioluli terminales 15 mm. longi, laterales brevissimi. Foliola crassa, obovato-oblonga, basi rotundata, breviter acuta, utroque latere nervis 8–10 percursa, supra obscure viridia velutino-pubescentia, subtus densissime incano-tomentosa, costula media aculeata, margine subaequaliter crenato-serrato, terminalia 5–8 cm. longa et 4 cm. vel ultra lata, in ramis floriferis minora obtusiora. Flores 3–4 in ramulis lateralibus racemosi; pedicelli 10–13 mm. longi ut calyces dense tomentosi, aculeolis sparsis armati. Sepala orbiculari-ovata, cuspidata, 7 mm. longa et 8 mm. lata; petala longiora pulchre coccinea.

COLOMBIA: Dept. of Cundinamarca, Paramo de Choachi, near Bogotá, alt. 3700 m.—"Low shrub, flowers deep red." *E. P. Killip & Brother Ariste-Joseph* 11967.—Flowering, August 8, 1922. (Type, U. S. National Herbarium, no. 1,140,050.)

Species ex subgenere "Orobatus" Focke, affinis *Rubo weberbaueri*, differt autem habitu robustiore, tomento eglanduloso, calycis lobis late ovato-deltoideis.

Rubus roseorum Berger, sp. nov.

Fruticosus. Caules floriferi teretes, brunnei, puberuli, aculeisque recurvis complanatis armati aliisque setiformibus sparsis asperi, superne ut petioli, pedunculi etc. glandulis stipitatis confertis vestiti. Folia inferiora quinata, superiora ternata, floralia simplicia; stipulae subulatae; petioli 5–6 cm longi, dense glandulosi, aculeisque 3–4 recurvis armati; petioluli consimiles, terminalis circ. 15 mm. longus. Foliola oblongo-lanceolata, breviter acuminata, basi rotundata vel vix cordata, terminale 6–7 cm. longum et ultra 3 cm. latum, lateralia minora, membranacea, costularum mucronibus dentibusque interjectis serrulata, costulae laterales 10–12, utrinque glabra, costulis tamen puberulis. Inflorescentiae terminalis inferne foliferae rami pedicellique albo-villosi glandulisque stipitatis brunneis muniti. Sepala ovato-deltoidea, utrinque albo-tomentosa glanduligera, petalis albis oblongis dimidio breviora.

ECUADOR: Vicinity of Quito. *J. N. Rose & George Rose* 23548. Flowering and fruiting, October 26 to November 1, 1918. (Type, U. S. National Herbarium, no. 1,023,038.) Chillo Valley; Santa Rosa, alt. 9600 ft. *H. E. Anthony & G. H. H. Tate* 204. Fruiting, August 26 to September 2, 1923.

Eubatus e grege *Adenotrichorum* Rydb. Frutex ut videtur e humilioribus, caules steriles adhuc ignoti.

I take pleasure in naming this species for Dr. J. N. Rose and his son, Mr. George Rose, who accompanied his father in 1918 to South America, and who always showed a great interest in plants, and did much good work.

Rubus killipii Berger, sp. nov.

Fruticosus. Rami floriferi teretes, minute tomentelli demum glabrescentes, aculeis raris vel deficientibus. Folia ternata; stipulae subulatae; petioli 6 cm. longi, minute tomentelli aculeisque nonnullis falcato-recurvis sat robustis armati; petiolulus terminalis 3 cm. longus, laterales 5 mm. longi. Foliola oblonga, utrinque rotundata, apice abrupte acuminata, coriacea, dura, glabra, supra nitidula obscure viridia nervis impressis tomentosulis, subtus pallidiora costaque aculeata, utrinque nervis lateralibus 8–10 rectangulariter patentibus prominentibus minute puberulis percursa, secus margines dentibus parvis minute mucronatis remote serrata; foliolum terminale circa 12–13 cm. longum et 9 cm. latum. Inflorescentiae amplae eximie multiflorae rami inferiores axillares circa 40 cm. longi, ut pedunculi pedicelli calycesque dense tomentosi. Pedicelli 1 cm. longi, bracteis deltoideis vel lanceolatis tomentosis muniti; calycis lobi ovato-deltoidei breviter cuspidati, 5–7 cm. longi reflexi; petala obovata obtusa 12 mm. longa rosea; stamina numerosa, carpella tomentosa.

COLOMBIA: Department of El Cauca, "La Gallera," Micay Valley, Cordillera Occidental. Clearing near Río San Joaquin, alt. 1100–1300 m. "Shrub, petals pink." *Ellsworth P. Killip* 7835. Flowering, June 29–30. 1922. (Type, U. S. National Herbarium, no. 1,142,423.) "The place where I collected this was about the most isolated imaginable, away down in the southwestern corner of Colombia. Two new genera and a number of new species have been found among these specimens." (E. P. Killip.)

Frutex ut videtur altus, copiose ramosus, floribundus et praepulcher, ex affinitate *Rubi florulenti*, Portoricensis plantae, sed robustior in omni parte, caulibus minus aculeatis, et foliis floribusque majoribus.

I take great pleasure in naming this species for Mr. E. P. Killip who has done so much for the exploration of the Colombian flora.

RADIO-TELEGRAPHY.—*Application of radio transmission phenomena to the problems of atmospheric electricity.*[1] J. H. DELLINGER, Bureau of Standards.

My remarks are in the nature of a brief progress report on the inter-relations of the problems of radio transmission phenomena and those of atmospheric electricity. While there is no novelty in the idea of this inter-relation, it having been prominently in the minds of many workers in both fields for years, it nevertheless does appear that recent radio developments will shed considerable light on the things with which the student of atmospheric electricity concerns himself. I hasten to say that the applications of the radio phenomena, which I have in mind, are applications to the underlying rather than to the immediate problems of atmospheric electricity and terrestrial magnetism. From the beginning of their study, the seat of the phenomena of atmospheric electricity has been obscure and it is becoming increasingly plain that the phenomena of radio wave propagation are attributable to the same seat. Indeed, I could equally have entitled my remarks "Application of atmospheric-electric phenomena to the problems of radio transmission."

There are two reasons for putting it the way I did, one having to do with the mode of conducting work in this field, and the other having to do with the question of who is to analyze and interpret the results. On the first point it is apparent that radio gives us a direct means of conducting controlled experiments on phenomena affected by the electrical conditions of the atmosphere, a means which is wholly impossible in the field of direct atmospheric-electric measurements. These means are being abundantly used; as you all know, radio experimentation is becoming very widespread and its results are increasingly fruitful. We are learning to select radio wave transmissions in particular directions, at particular times, and on particular frequencies, such as to produce an effect conditioned in a definite way upon electrical conditions in the atmosphere. Organization of such work is proceeding, from the sporadic work of the individual, to organized effort on a large scale. The second reason which I mentioned as determining the viewpoint chosen for this discussion, is simply that atmospheric electricity, rather than radio, is the science which must take the responsibility and the labor of deciphering the inner

[1] Presented before Section of Terrestrial Magnetism and Electricity, American Geophysical Union, April 30, 1925. Published by permission of the Director, Bureau of Standards.

relations between these various phenomena and the deduction of the underlying causes thereof. I shall return to this point later, and hope to justify it.

After much study of the available data and consideration of possible causes, radio science now considers that the major phenomena of radio wave transmission have their origin in the stratosphere. From the beginning of radio there have been efforts to find connections between characteristic radio transmission conditions and weather. By and large, the conclusion may now be stated that the effects of weather are minor in comparison with the effects of atmospheric electricity. Stated in another way, the major radio phenomena occur in the stratosphere rather than in the troposphere. I would not give the impression that weather conditions are entirely without effect on radio phenomena; if I were to make a comprehensive discussion of my subject I would be inclined to add to the title the words "and meteorology." However, the weather-radio phenomena are less definite and less certainly proved. For example, there is some indication that the strays or atmospheric disturbances of radio have some definite relation to maxima of pressure gradients as determined meteorologically, but in comparison with this tentative conclusion, slenderly supported, the evidence on the other hand is overwhelming that all radio-atmospheric disturbances have their origin in some form of atmospheric-electric discharges. C. T. R. Wilson's recent theory indicates that these discharges may not necessarily be lightning, but may, in large measure, be discharges taking place above the clouds. Here we see that the most likely explanations even of atmospherics can not neglect causes in the stratosphere.

The vagaries of radio wave transmission are so well known as to need no summarizing. The citizen listening to a broadcast program feels cheated when the signal intensity variation known as fading spoils his program. He is puzzled by the reports he hears that transmissions carried on with very high frequencies at certain times of day accomplish with very small power results which are impossible with very large power on the low frequencies. He is inclined to be impatient with the scientists and engineers because they can not eliminate these fluctuations and anomalies. Studies made during the past year and now still in progress are leading to a very considerable degree of understanding of these phenomena. The causes of the vagaries are pretty definitely localized in the stratosphere and are certainly closely tied in with the phenomena of atmospheric electricity. I shall

not attempt, in my few minutes, to summarize the behavior of high radio frequencies. Both popular and technical magazines are full of data and speculation on the subject.

Suffice it to say that these phenomena have thoroughly established the hypothesis proposed by Eccles in 1912 (and developed by Kennelly and others) which explain the great differences of distance of radio transmission at night and in the day by the daytime ionization of the air caused by the ultra-violet light in the sun's rays. The removal of this cause of ionization at night clears up the lower atmosphere so that the waves can penetrate to high altitudes at night. At some level in the atmosphere there must be a pressure so low that the permanent ionization above this level will render the medium conducting, thus providing something of the nature of a surface along which the waves can glide at night. Turbulence of the medium near this surface explains[1] fading (i.e., intensity fluctuations). A theory definitely worked out by Larmor during the past year has more firmly established this theory by showing that the effect of the interaction of the radio wave with the ionized particles leads to a bending down of the waves, thus establishing a calculable quasi-refraction which gives a real physical picture of the wave transmission and is a great advance over the conception of a wave sliding along a hypothetical conducting surface. Machinery of a very reasonable sort is thus established for the wave propagation.

This theoretical work comes simultaneously with the experimentally established facts of propagation of very high frequency waves without appreciable absorption, such remarkable effective propagation being observed even in the daytime when the frequency is sufficiently high. The remarkable thing about the Larmor theory is that it permits an explanation of new phenomena which had not hitherto been suspected, and enables a determination of the approximate height in the atmosphere of levels of various degrees of ionization from the observed effects of radio transmission in terms of the frequency, times of day, and other known factors of the transmission. I think it is sufficiently well known to you that with the very high frequencies there is a zone relatively near the transmitting station in which the waves can not be received at all but that beyond this zone they come in very effectively. An analogy which I like to use for the mechanism of transmission of radio waves is that of the German long range gun which bombarded

[1] *Radio signal fading phenomena.* J. H. DELLINGER and L. E. WHITTEMORE. THIS JOURNAL, **2**, p. 243: June 4, 1921.

Paris at a distance of 60 to 80 miles. The rarefied higher portions of the atmosphere which permitted the projectile to fly toward Paris with little resistance has a remarkable similarity to the atmospheric electric strata which, by their particular conditions of ionization, permit radio waves of a particular frequency to travel enormous distances around the earth.

This very fruitful theory is being supplemented by a very recent addition made by Messrs. Nichols and Schelleng of the Bell Telephone Laboratories and by English physicists, in which they have definitely worked out the additional effects caused by the interaction of the earth's magnetic field with the motions of the ionized atmospheric particles set up by the passing radio wave. Eccles had previously used the same theory to explain the variations of radio wave direction. This remarkable addition to the explanation of this phenomena is only a month old and it shows that some things, such for example as the predominance of radio fading at certain frequencies, are closely tied in with the effect of the earth's magnetic field as well as the differing ionization at various levels in the atmosphere.

I feel that I am speaking in generalities but that more specific explanation of the trend of current theory as well as the revelations of experiment would require very much more time than is at my disposal. Before I close I want to warn you against a number of current theories or, let us say, ways of referring to these radio phenomena, which are more or less in error. The first of these is the explanation of all these phenomena in terms of an alleged "Heaviside layer." Related to this is the ascribing to Heaviside of the current explanations of radio wave propagation phenomena. Heaviside did not know much about the phenomena of radio wave propagation and did not postulate a layer. What he did do was very valuable and still stands, namely the suggestion that at a certain height in the atmosphere a surface can exist, at which there is a greater or less discontinuity of conductivity, and that this can affect and assist the propagation of radio waves. Beyond this he did not go, and it seems to me that the expression "Heaviside surface" is in accordance with Heaviside's ideas but that the expression "Heaviside layer" is not. Since, furthermore, the recent theories of Larmor and of Nichols lead to the existence of numerous levels rather than a single level in the atmosphere which facilitate the propagation of waves at particular frequencies, even the expression "Heaviside surface" is no longer very useful.

Another misconception or instance of loose thinking is the ex-

planation of the wave propagation as reflection. I do not say that reflection may not eventually be established as the proper explanation, but the evidence is that the waves are guided by a conducting surface and that their propagation is in large part explained by a quasi-refraction caused by the interaction of the radio field intensity and the velocities of the ionized particles. Reflection in the true sense is not an accurate description of any phase of this process.

Another theory which I cannot accept and which is closely tied to the reflection theory is that the differing characters of propagation at different frequencies are due to differing heights of the strata which are effective; that is, the popular idea conceives the waves of varying frequency or wave lengths to be shot out from the transmitting antenna and that certain of them are reflected from a sort of sky mirror located at one height, and those of another frequency or wave length from a different sky mirror at a different height. These strata of differing conductivity doubtless exist and exist at different heights, but the phenomena which result are almost certainly not due to the difference in height of the strata but to the difference in character, that is, differing ionization and ionization gradient.

If I may be pardoned for still another attack on what I believe to be misconceptions I will refer to the rather free use of the idea of interference (as between light waves) as explaining fading. This again is tied in with the conception of propagation by reflection. Now it is almost inconceivable that the effective atmospheric strata are so uniform as to permit reflection of the uniform character that would be required to produce interference like that in optics, or that individual conditions of interference would not be statistically averaged out. The nature of the phenomena is such that the more probable explanation of the received intensity fluctuations is variable absorption in the medium caused by turbulence in the ionized strata. The result of this is that the wave arriving at a given receiving point is really a complex of waves from different directions, with differing intensities, phases, and polarizations. Variation in the air path of any part of this complex appears to the observer as a change in the resultant received wave. There is only one recorded instance that I know of which looks like genuine interference of optical type, and that is a series of remarkably regular fluctuations in received signal intensity obtained at the sunset period by five observers cooperating with the Bureau of Standards in some sunset transmission tests which closed on the 2nd of this month.

I would list the specific applications or inter-relations of radio phenomena and those of atmospheric electricity as in Table 1.

TABLE 1.—INTER-RELATIONS

ATMOSPHERIC ELECTRICITY	RADIO PHENOMENA
Lightning and thunder clouds	Atmospheric disturbances
Aurora and magnetic storms	Radio and electric line telegraph disturbances
Atmospheric potential gradient, and conductivity; diurnal and annual variations	Similar variations in atmospheric disturbances and field intensities
Earth's magnetic field and upper air conductivity	Differing radio wave propagation at various frequencies, distances, and directions

Summarizing, it is abundantly evident that the vagaries of radio transmission phenomena have an application to the problems of atmospheric electricity and terrestrial magnetism. In the latter field, fundamental explanations must make use of a system of currents in upper atmospheric strata which are subject to daily variations of ionization. In radio, we have a tool with which we can actually explore these strata and determine some of the facts having direct bearing on atmospheric electricity and the earth's magnetic field. Radio must leave to the science of atmospheric electricity the duty of deciphering the inter-relations between the two fields and applying them to the determination of fundamental causes. There are two reasons for this, first, radio is too fully engrossed with the determination of the immediate facts and applying them to the numerous important uses which are at hand, and second, there is no reason why radio should be concerned with going back of the immediate causes of the wave phenomena. The radio scientist will be happy indeed to get a reasonable picture of the wave transmission mechanism. He is not at all concerned with whether this mechanism is due to particles shot directly from the sun, cosmic dust, radioactive material in the air or soil, penetrating radiation, currents below ground, or lightning. A complete picture of the ionized strata in the atmosphere directly affecting his transmitted waves will satisfy him very well, and the deeper insight into the cause of this ionization and its characteristics he leaves to the worker in the larger field of atmospheric electricity.

SCIENTIFIC NOTES AND NEWS

An expedition to Africa to collect living giraffes, rhinoceroses, and other animals for the National Zoological Park will sail from New York March 20. The funds for the work have been presented to the Smithsonian Institution by WALTER P. CHRYSLER. The Expedition will consist of W. M. MANN, Director of the National Zoological Park, ARTHUR LOVERIDGE of the Museum of Comparative Zoology at Cambridge, Mass., and STEPHEN HAWEIS, artist, and will be accompanied by CHARLES CHARLTON, of the staff of the Pathe News.

The Petrologists' Club met at the home of F. E. WRIGHT on March 2. Program: T. S. LOVERING, *The need of certain physical constants in physical chemistry;* C. S. ROSS, *Replacement of igneous rock minerals in sedimentary beds;* A. C. SPENCER, *Alteration of plagioclase to sericite plus quartz;* F. E. WRIGHT, *The new geological map of South Africa.*

W. R. SMITH has resigned as geologist in the Alaska Branch of the U. S. Geological Survey.

SIDNEY PAIGE, chief of the Areal Geology Section of the U. S. Geological Survey, has accepted an engagement with the Amerada Corporation for work in South America.

G. N. COLLINS and F. E. KEMPTON sail March 17 for Haiti for the purpose of inaugurating experiments with perennial teosinte (Euchlaena perennis) and teosinte-maise hybrids. They plan to remain five or six weeks and cover the region between Port au Prince and Cape Hatien.